Journal of Applied Sciences 4 (2): 189-192, 2004
ISSN 1607-8926

Fluoride Content of Drinking Water Sources in Al-Gassim Region of Central Saudi Arabia

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Abstract: The quality of 160 water samples comprised of 27 well water (WW) samples 87 municipal network water (MNW) samples, 22 commercial municipal water (CMW) samples and 24 locally produced bottled water (LBW) samples, in AL-Gassin region of Central Saudi Arabia was investigated with respect to F^- concentration. The most salient features of the findings indicated that 55.6% of WW, 89.7% of MNW and 72.7% of CMW have F^- concentrations lying well below the recommended lower permissible level (0.6 mg L^{-1}) of the Saudi Standard (SASO)(1984) or even lower than 0.5 mg L^{-1} for many of the samples. Only very few of the samples investigated showed F^- levels above the maximum permissible level (1 mg L^{-1}) set by SASO. On the other hand, the F^- concentration of LBW samples investigated falls exclusively within the SASO (1984) range (0.6- 1 mg L^{-1}). Accordingly, the concentrations of F^- are alarming since an overwhelming majority of the samples investigated were below the lower permissible limit of 0.6 mg L^{-1} set by SASO (1984). The guideline of the WHO is 1.5 mg L^{-1} while the EEC and USEPA guidelines lie within the range of 0.7-1.5 and 2-4 mg L^{-1}, respectively. It is, therefore, recommended that a prompt fluoridation programme be considered for the respective sources.

Key words: Fluoride level, water sources, Central Saudi Arabia

INTRODUCTION

Among several chemicals in water known fluoride has been studied extensively under carefully controlled conditions both in laboratory and field. The benefits of F^- in reducing dental caries occur principally among young people who drink water containing low concentration of the chemical when their teeth are being formed. High or low levels of fluoride in drinking water sources have been found to cause adverse effects including all types of cancer, while optimum levels have beneficial effects on reducing dental caries[1,2,3,4,5]. Excessive amounts of fluoride above 4 mg L^{-1} in water supply result in skeletal fluorosis and teeth mottling whereas low levels (below 1 mg L^{-1}) result in diminishing dental caries[4,6]. The maximum health-based fluoride limit (based on a health risk of skeletal fluorosis) suggested by the USEPA is 4 ppm while the aethetic limit (cosmetically a health significant fluorosis, which is not considered a health risk) is 2 ppm[7]. Adachi *et al.*[19], depending on regional temperature, estimated the optimal fluoride level in water (the level that offers protection against dental caries with the least risk of fluorosis) at 0.7-1.2 mg L^{-1}.

In the Kingdom of Saudi Arabia the quality of drinking water is currently receiving considerable attention (Saudi Arabian Standards Organization (SASO)[8], Garawi *et al.*[9]). SASO developed drinking water standards for both municipal (unbottled) and bottled water to define a quality of water that is safe and acceptable to the consumer. These standards, depending on ambient temperature, set the limit for F at 0.6-1 mg L^{-1}. However, in the AL-Gassim Region of Central Saudi Arabia where there is a large dependence on the municipally approved and domestic bottled water sources, there are little or no comprehensive studies or follow up for the F^- status in drinking water supplies. In a previous study[10] indicated that municipal, well and domestically produced-bottled water contain average F^- levels of 0.4-0.6, 1.8 and 0.6, respectively.

The objective of this paper is to present the results of work carried out to assess the fluoride concentrations in drinking water sources in AL-Gassim Region of Central Saudi Arabia. It includes fluoride determination in well water, municipal distribution network water and commercial municipal water. The paper also discusses fluoride level in 24 locally produced bottled water samples.

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MATERIALS AND METHODS

Sample collection: Water samples were collected from 27 wells located in towns, villages and farms throughout AL-Gassim Region of Central of Saudi Arabia. Many of these wells water (WW) is used for drinking, domestic as well as agricultural purposes. Eighty-seven samples representing municipal network water (MNW) samples were obtained from water coolers and other containers used for drinking in mosques and public places. Commercial municipal water (CMW), (22 samples), was obtained directly from commercial drinking water service stations. These stations are supposed to maintain a fluoride concentration within a range of 0.6-1.0 mg L^{-1}. Twenty-four locally produced bottled water samples (LBW) were obtained from local supermarkets. Water samples for F^- analysis were collected in polyethylene bottles. The water samples were taken to the laboratory (Ambient temperature 25°C) and analysis was carried out immediately.

Analyses: The analyses were carried out according to the standards Methods for the Examination of Water and Wastewater[20,21]. In these methods F^- was determined by the SPADNAS [(Sodium 2-(parasulfo-phenylazo)-1,8 dihydroxy-3, 6 naphthalene disulfonate] colorometric methods using NAF for perpetration of the standard solution. Statistical analyses were preformed using SPSS statistical program. The means obtained for F^- concentration in the various drinking water sources were evaluated according to the current SASO[8]; World Health Organization (WHO)[12]; European Economic Community (EEC)[13] and (USEPA)United States Environmental Protection Agency[14] drinking water standards and guidelines.

RESULTS AND DISCUSSION

The results of this study provide a comprehensive picture on the level of F^- in well water, municipal network water, commercial municipal water and locally produced bottled water.

Table 1 presents the level of F^- in the various water sources investigated. The most salient feature of Table 1 is that with the exception of LBW the sources of water investigated have F^- level means well below the lower recommended permissible level of SASO[8] standard (0.6 mg L^{-1}) and other international drinking water standards listed in Table 3. Previous workers in the central region of Saudi Arabia obtained similar low levels for F^- in drinking water[15,16,3]. Conversely, very few of the water samples investigated showed F^- levels which are higher than the 1 mg L^{-1} maximum limit set by the SASO[8] standard as the highest F^- level for unbottled drinking water. Salem and AL-Gannam[2] reported F^- levels ranging between 0.95 and 14.85 mg L^{-1} in samples from eastern, northern and western Saudi Arabia. Accordingly, depending on the average ambient temperature prevailing in this part of the world, reaching as high as 45- 49°C, the consumption of drinking water during the summer season increases significantly. It is well known that consumption of high F^- level drinking water elicits undesirable and hazardous health effects because F^- can be an active toxicant and causes severe illness or death[11,1,7,4]. The rational for this temperature limitation is that the amount of water consumed by people varies with temperature and the recommended dosage of F^- in water, therefore, changes with ambient temperature to produce the desired total daily addition of F^- to the body.

Table 1: Levels of F^- in various water sources

Origin of sample	No. of samples	F^- level (mg L^{-1}) Mean	S.D¶	Minimum	Maximum
W.W	27	0.60	0.21	0.22	1.07
MNW	87	0.45	0.20	0.16	1.54
CMW	22	0.44	0.30	0.00	1.26
LBW	24	0.74	0.006	0.65	0.90

¶Standard deviation

Table 2: Distribution of F^- content(mg L^{-1}) in water samples

Origin of sample	F^- content (mg L^{-1}) 0-0.6	0.6-1	> 1
W.W	15 (55.6%)*	11(40.7%)	1(3.7%)
MNW	78 (89.7%)	7(8.0%)	2(2.3%)
CMW	16 (72.7%)	5(22.7%)	1(4.6%)
LBW	0.0 (0.0%)	24(100%)	0.0(0.0%)

* Figures in parenthesis indicate percentage of total

Table 3: Some international drinking water guidelines for fluoride

Parameter (mg L^{-1})	SASO (1984)	WHO (1993)	EEC (1992)	USEPA (1976)
F^-	0.6-1	1.5	0.7-1.5	2-4

Source: Anonymous[18].

Table 2 shows the distribution of F^- in the water samples examined. It shows that 55.6% of W.W, 89.7% of MNW and 72.7% of CMW samples investigated contain F^- level below 0.6 mg L^{-1}. Only 40.7% of W.W, 8.0% of MNW and 22.7% of CMW samples are within the range between 0.6- 1.0 mg L^{-1} F^- level recommended by SASO[8] while the LBW samples fall exclusively within this range. It is also worth of mentioning that about 33.3, 78.2 and 59.1% of the WW, MNW and CMW samples investigated are even below the F^- level of 0.5 mg L^{-1}, respectively. Moreover, it is clear from Table 2 that very few of the water samples investigated contain F^- levels > 1, the maximum permissible limit recommended by SASO. Similar results were obtained by Abdel Magid [10] and AL-Redhaiman and Abdel Magid[17].

Table 4: Comparison of the F^- level of the water sources investigated with the local and international drinking water standards

Water Source	SASO		WHO		EEC		USEPA	
	Below(0.6)	Above(1)	Below(1.5)	Above(1.5)	Below(0.7)	Above(1.5)	Below(2)	Above(4)
WW	15(55.6%)*	11(3.7%)	27(100%)	0.0(0.0%)	18(66.7%)	0.0(0.0%)	27(100%)	(0.0%)
MNW	78(89.7%)	2(2.3%)	86(98.9%)	1(1.2%)	81(93.1%)	1(1,2%)	87(100%)	(0.0%)
MCW	16(72.7%)	1(4.6%)	22(100%)	0.0(0.0%)	19(86.4%)	0.0(0.0%)	22(100%)	(0.0%)
LBW	0.0(0.0%)	0.0(0.0%)	24(100%)	0.0(0.0%)	1(4.2%)	0.0(0.0%)	24(100%)	(0.0%)

*No. and percentage(in parenthesis) of samples below or above each guideline (mg L^{-1})

A cross comparison of F^- level of the water sources investigated with the local and international drinking water standards (Table 4).

With the exception of LBW samples a high percentage of the water samples investigated have fluoride concentration lying well below the recommended lower permissible level of SASO standard[8]. The F^- level of almost all of the water samples investigated lie below the 1.5 mg L^{-1} maximum permissible limits set by the WHO and EEC guidelines for drinking water. As shown in Table 4 a vast majority of samples investigated (except for one LBW sample) are lower than the 0.7 mg L^{-1} F^- level set by EEC as the lower permissible limit. Moreover, none of the samples studied is in accord with either the lower or the higher USEPA recommended permissible limits. This indicates that the USEPA limits are not applicable under the temperature conditions prevailing in this part of the world. It may be inferred from the data obtained in this study, specially with respect to the fluoride concentrations lying below the recommended lower permissible level SASO[8] standards that supplemental fluoridation to the optimum level is deemed necessary to avoid dental decay in water consumers[3,4].

The fluoride content of four sources of drinking water supply viz., well water, municipal network water, commercial municipal water and locally produced bottled water was investigated. The significant features of the current findings indicated that, with the exception of locally produced bottled water, an overwhelming majority of the water samples investigated contain fluoride levels well below the recommended lower permissible level of SASO standard[8] as well as of the other international drinking water standards shown in Table 3. Locally produced bottled water F^- level falls exclusively within the range between 0.6-1.0 mg L^{-1}.

Based on the results of this study it may be stated that there is a crucial need to fluoridate the public water supplies mentioned above. Furthermore, it must be emphasized that continuous assessment of water quality with respect to fluoride is imperative and a better management is warranted to reduce the risk of low F^- water.

ACKNOWLEDGMENTS

The authors wish to expresses their sincere gratitude to the Agricultural and Veterinary Research Center of the College of Agriculture and Veterinary Medicine for funding this research.

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